89-e25

Segment No: 03-07-09
04-09-99

WA-07-0010

SCREENING SURVEY FOR CHEMICAL CONTAMINANTS AND TOXICITY IN DRAINAGE BASINS AT PAINE FIELD AUGUST 10-12, 1987

by
Art Johnson
Dale Norton

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Toxics Investigations/Ground Water Monitoring Section
Olympia, Washington 98504

May 1989

ABSTRACT

Water and sediment samples collected from six drainage basins below Paine Field, an airport and industrial/small business complex near Everett, Washington, were analyzed for the EPA priority pollutants/hazardous substances list compounds and subjected to 48-hour bioassays with *Daphnia pulex* (water samples) and 10-day bioassays with *Hyalella azteca* (sediment samples). Several instances of potentially significant chemical contamination were identified, the most noteworthy being a high concentration of PCB-1254 (20,500 ug/Kg, dry weight) in sediments at the outlet of a retention pond at the Boeing Commercial Airplane Company facility. Bioassays indicated most drainage water and sediments were non-toxic. Paine Field drainage did not appear to be an important source of chemical contamination to adjacent waters of Puget Sound.

INTRODUCTION

During August 10-12, 1987, and at the request of the Washington Department of Ecology (Ecology) Northwest Regional Office, personnel of the Toxics Investigations/Ground Water Monitoring Section of Ecology collected a series of water and sediment samples from drainage basins receiving runoff from Paine Field near Everett, Washington. These samples were analyzed for the U.S. Environmental Protection Agency (EPA) priority pollutants*/hazardous substances list (HSL) compounds and subjected to bioassays using two species of freshwater crustaceans--*Daphnia pulex* (a cladoceran) and *Hyalella azteca* (an amphipod). Data were also obtained on flow, conventional water quality variables (temperature, pH, turbidity, etc.), and ancillary physical/chemical characteristics of the sediments (grain size, total organic carbon, and percent moisture).

This report summarizes results of the survey and attempts to put the findings in perspective with regard to the following:

- EPA/Ecology water quality criteria
- Great Lakes sediment criteria
- Contaminant concentrations in local urban street dust
- Apparent effects thresholds (AET) for Puget Sound sediments
- Contaminant concentrations in adjacent Puget Sound sediments

Several instances of potentially significant chemical contamination were identified. The report concludes with recommendations for follow-up work to confirm these findings and evaluate the extent and source(s) of contamination.

---

* 2,3,7,8-Tetrachlorodibenzo-p-dioxin was not analyzed.

STUDY AREA

Paine Field is located southwest of Everett above the town of Mukilteo and overlooks Puget Sound to the west and north (Figure 1). The field and surrounding area contain the Snohomish County Airport, a U.S. Army and National Guard installation, two large industries, and a variety of small businesses. Runoff from the site reaches Puget Sound primarily through three drainage basins (Figure 2): Big Gulch (drainage area 3,440 acres) which drains west to Possession Sound, and Japanese Gulch (935 acres) and Powder Mill Gulch (1,280 acres) which drain north to Port Gardner. The upper portions of these heavily wooded basins are steep gullies, the lower portions are low gradient streams. Runoff going inland from Paine Field flows in a southerly direction to Stickney Lake, Swamp Creek and Marshy Lake via storm sewers and roadside ditches.

Big Gulch and Japanese Gulch receive runoff from the airport runway as well as urban runoff. The Olympus Terrace sewage treatment plant is located near the terminus of Big Gulch; its outfall (NPDES No. WA-002339-6) is in Possession Sound. The Mukilteo Defense Fuel Supply Depot, which stores aviation fuel, is located at the mouth of Japanese Gulch; it has storm water, fuel condensate, and fuels laboratory waste water discharges to Port Gardner (NPDES No. WA-002523-2). The Mukilteo sewage treatment plant, to the west of the fuel depot, also discharges to Port Gardner (NPDES No. WA-002329-9).

The Boeing Commercial Airplane Company and John Fluke Manufacturing Company, an electronics firm, are located above Powder Mill Gulch. Runoff from Boeing and the surrounding area is controlled by a retention pond that discharges to the gulch. Boeing (state discharge permit) and John Fluke (City of Everett discharge permit) effluents go to the Everett municipal sewage treatment plant.

According to Tetra Tech (1988a) there is a "long history of unpermitted landfills at the western and southern ends of the airport, including an old Air Force dump" capped in April 1987. Snohomish County site inspection logs are cited by Tetra Tech as listing a variety of potential problems such as waste containers labeled "poison" and "corrosive", overturned railroad tank cars, contaminated soil from landfills and sumps, and asphalt and tar wastes. A survey of the contents of 120 underground storage tanks in the area by the Paine Field Cleanup Committee found aviation fuel, kerosene, diesel, used oil, heating oil, #5 black oil, and gasoline (Tetra Tech 1988a). The Ecology Northwest Regional Office reports that spills are a common occurrence at Paine Field (Ashley 1987, personal communication).

METHODS

Sampling

Samples were collected from each of the six major drainage basins that receive Paine Field runoff: Big Gulch, Japanese Gulch, Powder Mill Gulch, Stickney Lake, Swamp Creek and Marshy Lake (Figure 3). Edgewater Creek, a small (200 acre) drainage between Japanese

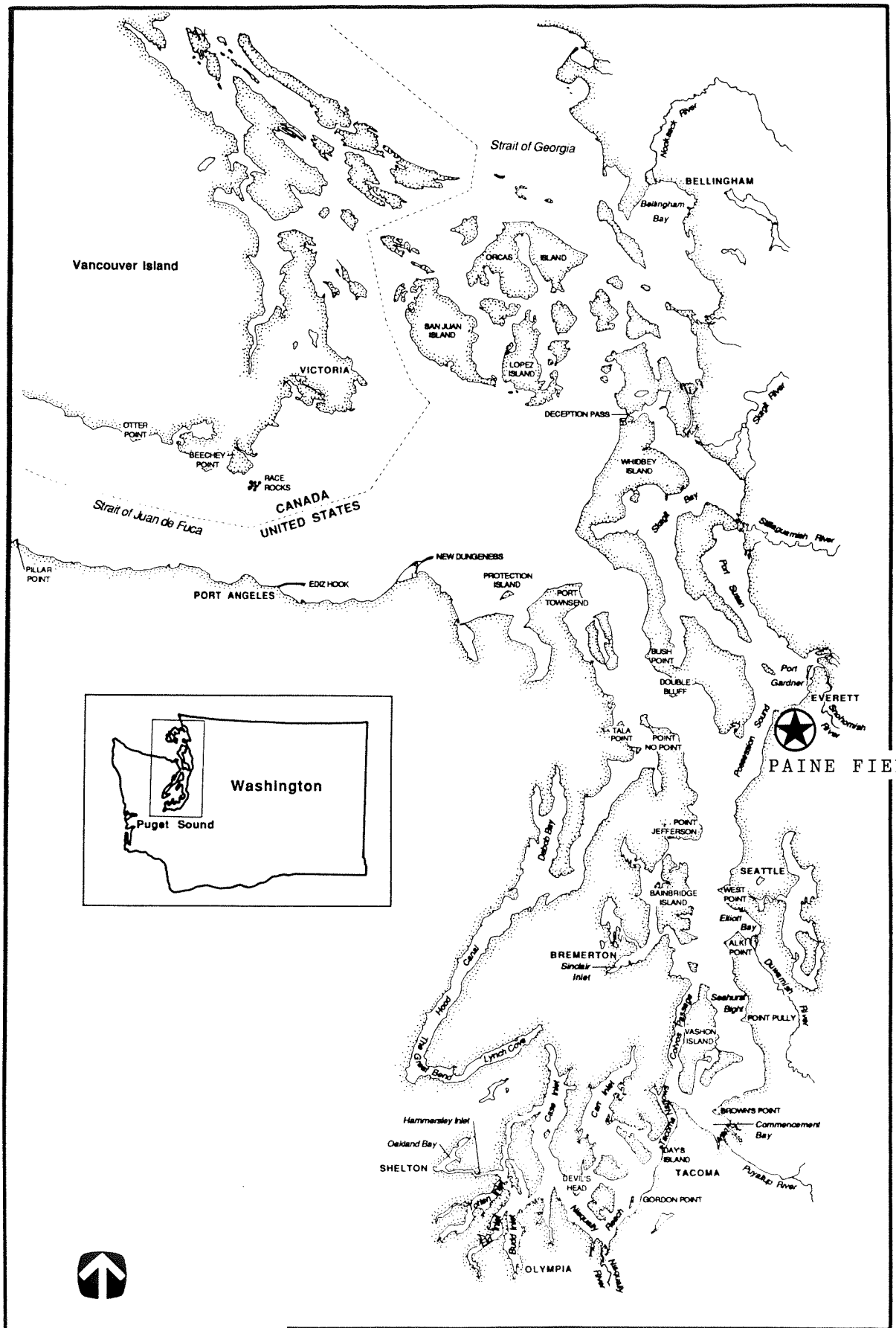

Figure 1. Map of Puget Sound showing location of Paine Field (Tetra Tech)

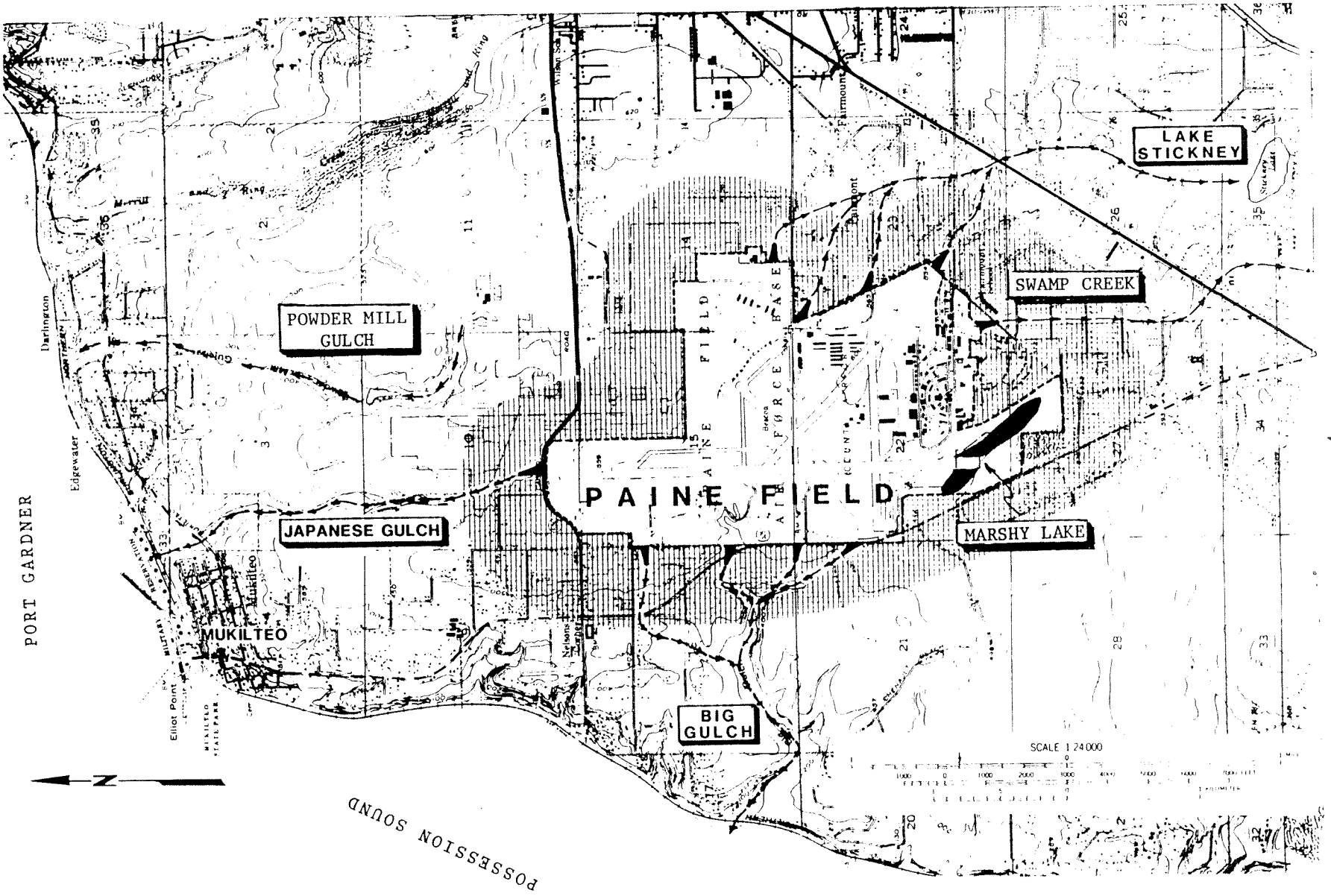

Figure 2. Paine Field drainage basins (from Reid, Middleton, & Associates, Storm Drain and Sanitary Sewer Study)

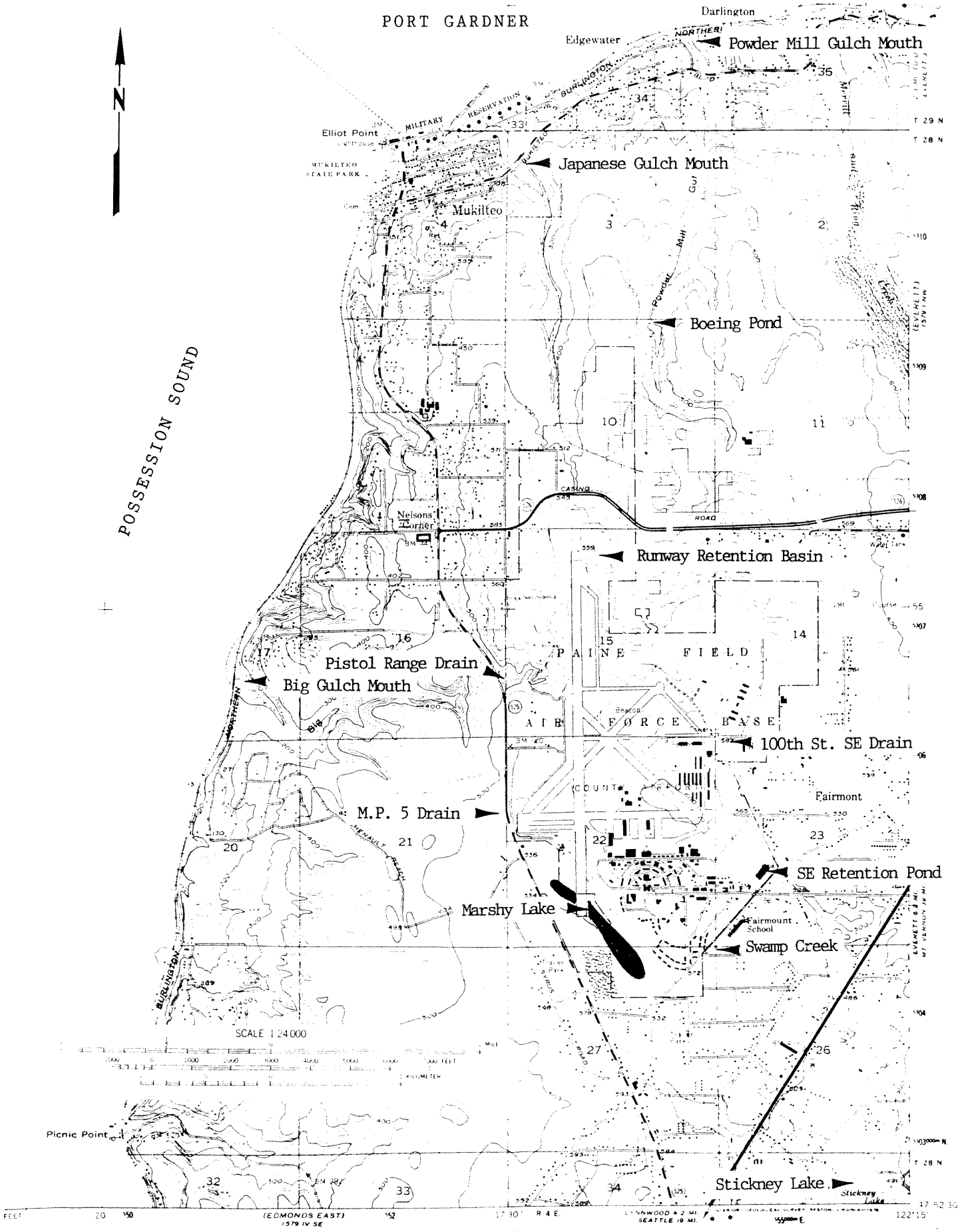

Figure 3. Sampling sites for Ecology Paine field survey of August 10-12, 1987

Gulch and Powder Mill Gulch, was not sampled. Where possible, both water and sediment samples were collected in the upper and lower portions of each drainage. No water samples were taken from lakes or in the upper portions of Big Gulch (at the Pistol Range Drain), Japanese Gulch, or Swamp Creek; the latter three sites being dry at the time of the survey. Swamp Creek was sampled only in the upper drainage; the nature of this site was more roadside ditch than creek. Boeing Pond samples were collected immediately upstream of the weir at the outlet structure.

Water samples were simple grabs. Flow was gaged with a Marsh-McBirney magnetic flow meter and top setting rod. Temperature (ASTM precision thermometer), and pH (Beckman model 21) were measured in the field.

Sediment samples were of the top 2-cm surface layer, collected with stainless steel spoons or stainless steel core tubes. Each sample was homogenized by stirring in stainless steel beakers prior to splitting into subsamples for chemical analyses and bioassays. Sediment sampling equipment was cleaned by washing with LiquiNox^{R} detergent followed by sequential rinses with de-ionized water, 10 percent nitric acid, de-ionized water, and pesticide-grade acetone. The equipment was then wrapped in aluminum foil.

All water and sediment samples were placed on ice immediately on collection and transported to the Ecology/EPA Environmental Laboratory in Manchester, Washington, the day following collection. Sample containers, preservatives and handling are described in Table 1.

Analysis and Quality Assurance (QA)

Analytical methods employed for the screening survey are given in Table 2. Chemical analyses followed recommendations of the Puget Sound Estuary Program (Tetra Tech 1986). Metals analysis of sediments used a strong acid digestion ($HN0_3/H_20_2$).

Internal laboratory QA followed routine Manchester laboratory procedures as described in Huntamer (1986) and Kirchmer (1988). Field QA samples included transport and transfer blanks for metals and organics analyses of water, and replicate water and sediment samples (collected at the mouth of Japanese Gulch). Holding times to extraction and analysis, and recoveries of matrix spikes and surrogate compounds spikes were within limits required by the EPA Contract Laboratory Program (CLP) except for the following:

- Volatiles analyses exceeded the 14-day holding time by about nine days; the data are considered acceptable for screening purposes only.

- Both method and field blanks for volatiles contained acetone (6.9 - 12 ug/L) and methylene chloride (1.2 - 84 ug/L); concentrations within these ranges were also detected in field samples. These compounds--which are common laboratory contaminants in trace organics analysis--are, therefore, not reported as being detected.

- N-nitrosodiphenylamine (52 ug/Kg), di-n-butylphthalate (50 ug/Kg), and bis(2-ethylhexyl)phthalate (1,500 ug/Kg) were detected in the method blank for

Table 1. Sample handling for Ecology Paine Field survey of August 10-12, 1987.

Variable	Sample Container[a]	Preservative	Maximum Holding Time
WATER SAMPLES:			
Specific conductivity, hardness, suspended solids, turbidity	1 liter polyethylene	Cool to 4°C	turbidity-2 days, suspended solids-7 days, specific conductivity-28 days, hardness-6 months
Nutrients	250 mL polyethylene	H_2SO_4 to pH <2, Cool to 4°C	28 days
Total organic carbon	40 mL glass with teflon lid liner	H_2SO_4 to pH <2, Cool to 4°C	28 days
Oil and grease	1 quart glass	Cool to 4°C	28 days
Metals	1 quart polyethylene with teflon lid liner	Cool to 4°C, HNO_3 to pH <2 (lab)	6 months 28 days for Hg
Cyanide	250 mL polyethylene	NaOH to pH >12, Cool to 4°C	14 days
Volatiles	40 mL glass with teflon septum	Cool to 4°C	14 days
Acid/base/neutrals	1 gallon glass with teflon lid liner	Cool to 4°C	7 days until extraction 40 days after extraction
Daphnia bioassay	1 gallon glass with teflon lid liner	Cool to 4°C	3 days
SEDIMENT SAMPLES:			
Grain size	polyethylene bag	Cool to 4°C	6 months
Total organic carbon	4 oz. glass with teflon lid liner	Cool to 4°C	6 months
Percent moisture	4 oz. glass with teflon lid liner	Cool to 4°C	6 months
Metals	4 oz. glass with teflon lid liner	Cool to 4°C	6 months
Acid/base/neutrals	4 oz. glass with teflon lid liner	Cool to 4°C	14 days until extraction 40 days after extraction
Pesticides/PCB	4 oz. glass with teflon lid liner	Cool to 4°C	14 days until extraction 40 days after extraction
Hyalella bioassay	1/2 gal. glass with teflon lid liner	Cool to 4°C	14 days

[a] Cleaning procedures described in Huntamer (1986).

Table 2. Analytical methods for Ecology Paine Field survey of August 10-12, 1987.

Variable	Analytical Method	Reference	Laboratory
WATER SAMPLES:			
Specific conductivity	conductivity bridge, Method 205	APHA (1985)	Ecology/EPA, Manchester, WA
Total hardness	EDTA titrimetric, Method 314B	APHA (1985)	Ecology/EPA, Manchester, WA
Suspended solids	gravimetric, 103-105°C, Method 160.2	EPA (1983)	Ecology/EPA, Manchester, WA
Turbidity	nephelometric, Method 214A	APHA (1985)	Ecology/EPA, Manchester, WA
Ammonia	automated phenate, Method 305.1	EPA (1983)	Ecology/EPA, Manchester, WA
Nitrate-nitrite	automated cadmium reduction, Method 353.2	EPA (1983)	Ecology/EPA, Manchester, WA
Total phosphorus	automated ascorbic acid, Method 365.1	EPA (1983)	Ecology/EPA, Manchester, WA
Total organic carbon	persulfate-ultraviolet, Method 505	APHA (1985)	Ecology/EPA, Manchester, WA
Oil and grease	gravimetric, spectrophotometric, Method 413.1	EPA (1983)	Ecology/EPA, Manchester, WA
Metals (total recoverable)	AA/ICP	EPA Contract Lab Program SOW No. 785 (7/85)	Weyerhaeuser, Tacoma, WA
Total cyanide	titrimetric, spectrophotometric, Method 335.2-1	EPA (1983)	Ecology/EPA, Manchester, WA
Volatiles	purge and trap GC/MS, Method 624	EPA (1984a)	Analytical Resources Inc., Seattle, WA
Acid/base/neutrals	GC/MS, Method 625	EPA (1984a)	Ecology/EPA, Manchester, WA
Daphnia bioassay	48-hour static	EPA (1985a)	Ecology/EPA, Manchester, WA
SEDIMENT SAMPLES:			
Grain size	sieves and pipets	Holme & McIntyre (1971)	Parametrix Inc., Bellevue, WA
Total organic carbon	induction furnace	In-house	Laucks Testing Laboratories Inc. Seattle, WA
Percent moisture	dry @ 105°C	APHA (1985)	Laucks Testing Laboratories Inc. Seattle, WA
Metals	AA/ICP	EPA (1986a)	Weyerhaeuser, Tacoma, WA
Acid/base/neutrals	GC/MS, Method 3540	EPA (1986a)	Ecology/EPA, Manchester, WA
Pesticides/PCB	GC/MS, Method 3540	EPA (1986a)	Ecology/EPA, Manchester, WA
Hyalella bioassay	10-day static	Nebeker et al., (1984)	Ecology/EPA, Manchester, WA

acid/base/neutrals analysis of sediments. Phthalates are also common laboratory contaminants. Because concentrations measured in field samples were comparable to, or less than those in the method blank, these compounds are not reported detected.

- Pentachlorophenol was not recovered in either of the duplicate matrix spikes of sediment. The present survey did not, therefore, adequately assess the occurrence of this compound in the sediments.

- Benzyl alcohol, bis(2-isoprophyl)ether, n-nitrosodiphenylamine, 3,3'-dichlorobenzidine, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate were detected in field and/or method blanks for acid/base/neutrals analysis of water and are, therefore, not reported detected.

- 2-Nitroaniline and 4-nitroaniline were outside CLP quality control limits for acid/base/neutrals analysis of water and, consequently, not adequately assessed in water samples.

RESULTS AND DISCUSSION

General Water Quality in the Drainage Basins

The survey was conducted under conditions of dry weather. The last measurable precipitation at Everett, prior to sampling, was 0.1 inch 35 days eariler on July 6 (NOAA 1987). Flows ranged from a low of 0.01 cubic feet per second (cfs) in the Mile Post (M.P.) Drain to Big Gulch and at the outlet from the S.E. Paine Field Retention Pond, to a high of 2.2 cfs at the mouth of Powder Mill Gulch (Table 3). Flows in the three drainages to Puget Sound decreased in the order Powder Mill Gulch (2.2 cfs), Japanese Gulch (0.87 cfs) and Big Gulch (0.07 cfs). The Boeing Retention Pond was contributing about 10 percent of the total flow in Powder Mill Gulch at the time of the survey.

There was evidence of eutrophication in several drainage basins. EPA (1986b) has recommended T-$P0_4$ (as P) concentrations not exceed 0.1 mg/L to prevent plant nuisances in streams. This concentration was exceeded at the mouth of Japanese Gulch (0.11-0.12 mg/L), the mouth of Powder Mill Gulch (0.18 mg/L), the 100th St. S.E. Ditch (0.13 mg/L), and the S.E. Retention Pond (0.51 mg/L). Boeing Pond (0.38 mg/L) was a source of phosphorus to Powder Mill Gulch, but the pond discharge (0.22 cfs) was not sufficient to account for the elevated the phosphorus concentration at the mouth of the gulch (0.18 mg/L, 2.2 cfs), suggesting there were additional sources in the drainage. Based on N:P ratios in EPA (1985b), eutrophication problems are likely to occur in Powder Mill Gulch, and severe problems are possible in the S.E. Retention Pond. An algal bloom appeared to be occurring in the pond at the time of the survey.

Aesthetically, the M.P. 5 Drain to Big Gulch and the 100th St. Ditch had severe water quality problems. The M.P. 5 Drain was foamy and the bottom was covered with a reddish-brown floc. This drain had the highest specific conductivity, ammonia, hardness, and total organic carbon (TOC) observed among the drainages surveyed. Its turbidity was second only to the

Table 3. General water quality of Paine Field drainages, August 1987.

Drainage:	Big Gulch		Japanese Gulch		Powder Mill Gulch		Stickney Lake	
Location:	Mile Post 5	Mouth	Mouth	Mouth (Replicate)	Boeing Retention Pond Outlet	Mouth	100th St SE Ditch	SE Retention Pond Outlet
Date:	8/10	8/10	8/10	8/10	8/12	8/11	8/10	8/12
Time:	11:00	12:05	13:55	14:00	10:45	11:15	16:30	11:30
Sample No. (33-):	8162	8165	8169	8170	8179	8175	8181	8182
Flow (cfs)	0.01	0.07	0.87	--	0.22	2.2	0.12	0.01
Temperature (^{o}C)	11.7	15.1	11.4	--	18.0	13.4	19.1	18.6
pH (S.U.)	7.6	8.2	7.8	7.8	7.9	8.0	7.1	8.9
Spec. Conduct. (umhos/cm)	576	336	254	252	154	159	75	174
T-NO_2+NO_3 as N (mg/L)	0.11	1.0	0.57	0.92	0.35	1.1	0.03	1.4
T-NH_3+NH_4 as N (mg/L)	0.33	0.05	0.04	0.04	0.02	0.01	0.02	0.06
T-PO_4 as P (mg/L)	0.03	0.05	0.11	0.12	0.38	0.18	0.13	0.51
T. Hardness as $CaCO_3$ (mg/L)	313	162	135	123	55	77	41	72
T. Susp. Solids (mg/L)	4	1U	4	8	1U	12	3	4
Turbidity (NTU)	16	1U	4	3	1	2	23	8
T. Org. Carbon (mg/L)	16	8	7	6	4	2	14	6
Oil & Grease (mg/L)	1U	1U	1U	1U	1U	1U	19	1U

U = not detected at detection limit shown

100th St. Ditch which had recently been contaminated by a spill of cutting fluid from a Paine Field shop on July 21 (Ashley 1987, personal communication). This spill is also reflected in the elevated concentration of oil and grease in the ditch, and may be responsible for one or more of the several synthetic organic compounds detected here (see results of organics analyses).

Temperature, pH, and turbidity at the mouths of Big Gulch, Japanese Gulch and Powder Mill Gulch were within Washington state Class A water quality standards. Dissolved oxygen and fecal coliform bacteria data were not obtained during the survey.

Metals Concentrations in the Drainage Basins

Water (Table 4)--Seven of the 13 metals analyzed--antimony, arsenic beryllium, nickel, selenium, silver and thallium--were at or below detection limits (1 ug/L or less depending on the metal in question) in all drainage waters. Cadmium was detected only in the 100th St. Ditch. Low concentrations of chromium, copper, lead, mercury, and zinc were detected in most water samples.

In a few cases, metals concentrations exceeded EPA/Ecology (1986b) criteria for protection of aquatic life*. Zinc (116 ug/L) and copper (10 ug/L) concentrations in Boeing Pond's discharge to Powder Mill Gulch exceeded the acute exposure criterion for zinc (71 ug/L) and the chronic criterion for copper (7.1 ug/L). Elevated concentrations of these metals were not, however, observed downstream at the mouth of Powder Mill Gulch. The 100th St. Ditch had a lead concentration (116 ug/L) in excess of the acute criterion (53 ug/L) and a cadmium concentration (3.5 ug/L) above the chronic criterion (0.56 ug/L).

Mercury concentrations at the mouth of Big Gulch (0.22 ug/L) and the outlet from the S.E. Retention Pond (0.28 ug/L) exceeded the EPA/Ecology chronic exposure criterion (0.012 ug/L) but not the acute criterion (2.4 ug/L). The method detection limit for mercury was not sufficiently low to judge chronic criterion conformance at other sites. This criterion is intended to keep mercury concentrations in edible tissues of fish below the FDA action level of 1 part per million, rather than prevent acute or chronic toxicity to aquatic life.

Metals loads represented by the above concentrations were not large. The maximum instantaneous load measured was 0.2 lb per day for zinc at the mouth of Powder Mill Gulch. Other metals loads were 0.1 lb per day or less.

---

* EPA/Ecology water quality criteria for cadmium, chromium, copper, lead, nickel, silver, and zinc vary with hardness. Table 4 shows criteria for a total hardness of 77 mg/L (as $CaCO_3$). This is the lowest value measured among Big Gulch, Japanese Gulch, and Powder Mill Gulch during the present survey. Lower hardness values were measured in other drainages where data on metals in water were obtained, but these have little value as aquatic habitat. The criteria cited in the text above as being exceeded in a particular sample were adjusted to the hardness measured in that sample.

Table 4. Metals analysis of water samples collected from Paine Field drainages August 1987 compared to EPA/Ecology water quality criteria (ug/L; ppb, total recoverable metal).

Drainage:	Big Gulch		Japanese Gulch		Powder Mill Gulch		Stickney Lake				EPA/Ecology Water Quality Criteria[a]	
Location:	Mile Post 5	Mouth	Mouth	Mouth (Replicate)	Boeing Retention Pond Outlet	Mouth	100th St SE Ditch	SE Retention Pond Outlet	Transfer Blank	Transport Blank	Chronic: 4-day average (not to be exceeded more than once every three years)	Acute: 1-hour average
Date:	8/10	8/10	8/10	8/12	8/12	8/11	8/10	8/12				
Time:	11:00	12:05	13:55	14:00	10:45	11:15	16:30	11:30	13:55	--		
Sample No. (33-):	8162	8165	8169	8170	8179	8175	8181	8182	8171	8172		
Antimony	**1.8**	**2.0**	**2.1**	**2.0**	**0.8**	**2.4**	**0.8**	**3.0**	**0.8U**	**0.8U**	190	360
Arsenic	1U	1U	1U	1U	**1**	1U	1U	1U	1U	1U	1600	9000
Beryllim	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	5.3	130
Cadmium	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	**3.5***	0.2U	0.2U	0.2U	0.92	2.9
Chromium	**1**	**0.8**	**3**	**1**	**2**	**3**	**5**	**18**	**2**	**0.7**	170	1400
Copper	**2**	**3**	**2**	**2**	**10***	**2**	**9**	**7**	**1**	**1**	9.5	14
Lead	**0.6**	**0.6**	**4.9**	**2.2**	**2.6**	**1.0**	**116***	**1.4**	**0.6**	**0.6**	2.3	58
Mercury	0.06U	**0.22***	0.06U	0.06U	**0.06**	0.06U	**0.06**	**0.28***	0.06U	0.06U	0.012	2.4
Nickel	2U	2U	**2**	2U	2U	2U	2U	**3**	2U	2U	130	1100
Selenium	0.6U	0.6U	0.6U	0.6U	0.6U	0.6U	0.6U	0.6U	0.6U	0.6U	35	260
Silver	0.7U	0.3U	0.3U	0.3U	0.3U	0.3U	**0.3**	0.3U	0.3U	0.3U	0.12	2.6
Thallium	0.6U	0.6U	0.6U	0.6U	**0.6**	0.6U	**0.6**	0.6U	0.6U	0.6U	40	1400
Zinc	**2**	**1**	**9**	**7**	**116***	**15**	**20**	**6**	**1**	**1**	85	94

U = not detected at detection limit shown

* exceeds chronic and/or acute water quality criteria

[a] calculated for a total hardness of 77 mg/L (see text) except beryllium, antimony, arsenic, mercury, silver (chronic criteria) and thallium which are independent of hardness; example: zinc chronic criterion = e exp (0.8473[ln (hardness)]+0.7614)

Drainage waters were also analyzed for cyanide. A total cyanide concentration of 48 ug/L was measured at the outlet from the S.E. Retention Pond. Cyanide was not detected in water from other drainage basins (5 ug/L detection limit). EPA/Ecology criteria for free cyanide in freshwaters are 5.2 ug/L (acute exposure) and 22 ug/L (chronic exposure) and may, therefore, have been exceeded in the S.E. Retention Pond.

Sediments (Table 5)--Sediment texture and, to a lesser extent, organic carbon content were variable within and between drainage basins. Samples from Big Gulch were finer textured (20.1 - 50.3 percent fines) than either Japanese Gulch or Powder Mill Gulch (7.7-18.9 percent fines). TOC was comparable (0.5-1.5 percent) between the three basins. Sediments from ponds and lakes tended to have the highest fines and organic content.

Antimony, beryllium, selenium, and thallium were below detection limits (2-6 mg/Kg; 30 mg/Kg for antimony) in all sediment samples. Cadmium was detectable only in sediments from Boeing Pond and the 100th St. Ditch; silver was detectable in Swamp Creek sediments only. Most drainage sediments had detectable amounts of arsenic, chromium, copper, lead, mercury, nickel, and zinc.

To determine if metals concentrations in the sediments may have adverse impacts within drainage basins or pose a concern for their receiving environments, the data were compared to available criteria for fresh water sediments, apparent effects thresholds (AET) for Puget Sound marine sediments, and metals concentrations in urban street dust (Table 5). This approach was recommended by Tetra Tech (1988b) as a means of identifying toxic contamination in urban storm drains, especially those discharging to Puget Sound. The criteria are described briefly below:

- Freshwater Sediment Criteria--Criteria analogous to EPA/Ecology water quality criteria do not exist for freshwater sediments. Sediment criteria development for Washington state has been limited to marine sediments. Interim criteria for metals in freshwater sediments have, however, been established for the Great Lakes by the Wisconsin Department of Natural Resources (1985). In-lake disposal of dredged material is not allowed if one or more metals concentrations exceed the criteria by 25 percent. The criteria, which are limited to metals, were developed from comparison of current and historical levels of contamination in Great Lakes sediments.

- Puget Sound AET--An AET is the sediment concentration of a chemical above which a statistically significant biological effect (relative to reference sediments) is always observed, based on results from up to 284 stations in Puget Sound (PTI Environmental Services 1988). The biological indicators used in deriving effects thresholds are depressions in benthic infauna, and results of amphipod (*Rhepoxynius abronius*), oyster larvae (*Crassostrea gigas*), and Microtox^{R} bioassays. For purposes of the present survey, only those drainages discharging to Puget Sound were compared to AET values. Where drainage sediments exceed AET values, toxic effects may occur in the receiving environment without dilution by uncontaminated sediments.

Table 5. Metals analysis of sediment samples collected from Paine Field drainages August 1987 compared to criteria for contaminated sediments (mg/Kg, dry; ppm).

Drainage:	Big Gulch			Japanese Gulch			Powder Mill Gulch					
Location:	Mile Post 5 Drain	Pistol Range Drain	Mouth	Runway Retention Basin Outlet	Mouth	Mouth (Replicate)	Boeing Retention Pond Outlet	Mouth		Puget Sound AET Values[b]		
Date:	8/10	8/10	8/10	8/11	8/10	8/10	8/11	8/11				
Time:	11:00	11:30	12:05	15:00	13:55	14:00	09:15	11:15	Freshwater Sediment Criteria[a]	Lowest AET	Highest AET	Urban Street Dust[c]
Sample No. (33-_)[d]:	8161	8163	8164	8166	8167	8168	8173	8174				
% Fines	34.85	20.13	50.32	18.94	10.71	7.66	48.04	9.15				
% TOC	1.5	1.0	0.5	0.8	1.4	0.8	4.2	0.5				
% Moisture	52.9	21.7	35.9	1.0	53.8	42.5	49.6	24.6				
Antimony	30U	30U	30U	30U	30U	30U	30U	30U	--	150	200	1.1
Arsenic	**11**	**4**	**8**	**5**	**28***	**13***	**10**	**2**	10	57	700	25
Beryllim	2U	2U	2U	2U	2U	2U	2U	2U	--	--	--	0.26
Cadmium	2U	2U	2U	2U	2U	2U	**8.6***	2U	1.0	5.1	9.6	1.0
Chromium	**22**	**33**	**51**	**34**	**33**	**25**	**67**	**33**	100	--	--	97
Copper	**8.7**	**12**	**25**	**13**	**21**	**14**	**85**	**12**	100	390	1300	93
Lead	**10**	**6.3**	**5.2**	**5.8**	**68**	**32**	**214***	**7.1**	50	450	660	520
Mercury	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	**0.27***	0.04U	0.10	0.41	2.1	0.07
Nickel	**22**	**35**	**55***	**44***	**43***	**34**	**57***	**37***	100	>140	>140	32
Selenium	2U	2U	2U	2U	2U	2U	2U	2U	--	--	--	2
Silver	2U	2U	2U	2U	3U	2U	2U	2U	--	>0.56	>5.9	0.32
Thallium	2U	2U	2U	2U	2U	2U	2U	2U	--	--	--	0.06
Zinc	**44**	**46**	**63**	**47**	**181**	**112**	**908***	**131**	100	410	1600	310

U = not detected at detection limit shown

* exceeds one or more sediment criteria

[a] interim dredge disposal criteria for Great Lakes; cannot exceed 125% of criteria value (Wisconsin Dept Natural Resources 1985)

[b] apparent effects thresholds; concentrations above which statistically significant biological effects occur in all samples analyzed (PTI 1988)

[c] mean of 12 samples from Seattle and Bellevue (Galvin and Moore 1982)

[d] silt + clay (<62 um)

Table 5. (continued).

Drainage:	Stickney Lake			Swamp Creek	Marshy Lake		
Location:	100th St SE Ditch	SE Retention Pond Outlet	N. End of Lake	Bev. Pk./ Edmonds Rd.	E. Side of Runway		
Date:	8/10	8/11	8/11	8/10	8/11		
Time:	16:30	16:30	13:45	16:45	16:00		
Sample No. (33-):	8176	8177	8178	8180	8160	Freshwater Sediment Criteria[a]	Urban Street Dust[b]
% Fines[c]	5.47	89.64	86.92	39.80	94.25		
% TOC	0.6	2.6	15	19	2.2		
% Moisture	76.5	42.7	13.5	30.4	61.8		
Antimony	30U	30U	90U	90U	30U	--	1.1
Arsenic	**3**	**6**	**21***	**19***	**11**	10	25
Beryllim	2U	2U	6U	6U	2U	--	0.26
Cadmium	**5.7***	2U	6U	6U	2U	1.0	1.0
Chromium	**44**	**85**	**49**	**39**	**85**	100	97
Copper	**25**	**33**	**45**	**32**	**48**	100	93
Lead	**213***	**39**	**174***	**36**	**32**	50	520
Mercury	**0.11***	**0.09**	**0.39***	**0.24***	**0.18***	0.10	0.07
Nickel	**44***	**55***	**58***	**35**	**91***	100	32
Selenium	2U	2U	6U	6U	2U	--	2
Silver	2U	2U	6U	**7***	2U	--	0.32
Thallium	2U	2U	6U	6U	2U	--	0.06
Zinc	**96**	**191***	**352***	**188***	**271***	100	310

Note: Puget Sound AET value not applicable to above drainages

U = not detected at detection limit shown

[a] interim dredge disposal criteria for Great Lakes; cannot exceed 125% of criteria value (Wisconsin Dept. Natural Resources 1985)

[b] mean of 12 samples from Seattle and Bellevue (Galvin and Moore 1982)

[c] silt + clay (<62 um)

- Urban Street Dust--Because street dust is the primary source of suspended particulates in urban runoff, sediments in drainages receiving urban runoff often exceed AET values (Tetra Tech 1988a). Contaminant levels in street dust may, therefore, be representative of background levels in some Paine Field drainage basins. (It should be recognized, however, that contaminant levels typical of street dust may pose a hazard to aquatic life.)

Table 6 summarizes instances were metals concentrations in sediments from Paine Field drainages exceeded one or more of the above criteria. Note that the method detection limits for antimony, beryllium, silver, and thallium were substantially above one or more of the sediment criteria.

When compared to urban dust concentrations, nickel appeared elevated in all drainages except Swamp Creek. However, concentrations did not exceed Puget Sound AET or Great Lakes sediment criteria.

The primary metals problem identified in drainages to Puget Sound was in Boeing Pond where concentrations of cadmium (8.6 mg/Kg), lead (214 mg/Kg), mercury (0.27 mg/Kg), and zinc (908 mg/Kg) exceeded one or more sediment criteria. As noted earlier, the water sample from the pond outlet also had a zinc concentration in excess of EPA/Ecology water quality criteria. The Boeing discharge did not appear to have an impact on downstream metals concentrations in sediments (or water) at the mouth of Powder Mill Gulch, except for zinc (131 mg/Kg) which was above Great Lakes sediment criteria. Arsenic and zinc concentrations at the mouth of Japanese Gulch were also above Great Lakes sediment criteria; neither metal was elevated in water samples from the gulch.

Elevated concentrations of several metals were observed in sediments from the Stickney Lake and Swamp Creek drainages, and in Marshy Lake. Foremost among these were cadmium (5.7 mg/Kg) and lead (231 mg/Kg) in the 100th St. Ditch, mercury (0.39 mg/Kg) and zinc (352 mg/Kg) in Stickney Lake, and silver (7 mg/Kg) in Swamp Creek, all of which exceeded average values for local urban street dust. Sediments from Stickney Lake appeared to be contaminated by a range of metals, as arsenic (21 mg/Kg) and lead (174 mg/Kg) concentrations also exceeded Great Lakes sediment criteria.

Organic Compounds Detected in the Drainage Basins

Water (Table 7)--The detection of volatile organic compounds was limited to a trace of chloroform (1.5 ug/L) in the Boeing Pond discharge and several chlorinated ethenes and ethanes (1.1 - 56 ug/L), and chloroform (3.2 ug/L) in the 100th St. Ditch. The only acid/base/neutral compounds detected in water were in the 100th St. Ditch, these being naphthalene (2 ug/L), 1,2-dichlorobenzene (71 ug/L), 1,4-dichlorobenzene (8 ug/L), and 2,4-dimethylphenol (94 ug/L). The previously mentioned spill of cutting fluid is a likely source of one or more of the contaminants detected in the ditch. EPA/Ecology water quality criteria for aquatic life for the above compounds are orders of magnitude higher than concentrations measured in either discharge.

Table 6. Instances where metals concentrations in Paine Field drainages sediment samples collected August 10-12, 1987, exceeded various sediment quality criteria.

Drainage	Location	>Great Lakes Sediment Criteria	>Puget Sound AET Values Lowest AET	Highest AET	>Urban Street Dust
Big Gulch	Mile Post 5	--	--	--	--
	Pistol Range	--	--	--	--
	Mouth	--	--	--	nickel
Japanese Gulch	Runway Retention Pond Outlet	--	--	--	--
	Mouth	arsenic zinc	--	--	nickel
Powder Mill Gulch	Boeing Retention Pond Outlet	cadmium lead mercury zinc*	cadmium mercury zinc*	--	cadmium mercury nickel zinc*
	Mouth	--	--	--	nickel
Stickney Lake	100th St. SE Ditch	cadmium* lead*	(criteria not applicable)		cadmium* mercury nickel
	SE Retention Pond Outlet	zinc	(criteria not applicable)		nickel
	N. End of Lake	arsenic lead mercury zinc	(criteria not applicable)		mercury nickel zinc
Swamp Creek	Bev.Pk.-Edmonds Rd.	arsenic mercury zinc	(criteria not applicable)		mercury silver
Marshy Lake	East Side of Runway	mercury zinc	(criteria not applicable)		mercury nickel

* metal also exceeded EPA water quality criteria in water sample from this site

Table 7. Organic compounds detected in water samples collected from Paine Field drainages, August 1987 (µg/L; ppb).

Drainage	Location	Date	Time	Sample No. (33-)	Compound	Concentration
Powder Mill Gulch	Boeing Retention Pond Outlet	8/12	10:45	8179	chloroform	1.5
Stickney Lake	100th St. SE Ditch	8/10	16:30	8181	chloroform	3.1
					1,1-dichloroethane	5.6
					trans-1,2-dichloroethene	1.1 J
					1,1,1-trichloroethane	56
					trichloroethene	28
					naphthalene	2 J
					1,2-dichlorobenzene	71 J
					1,4-dichlorobenzene	8 J
					2,4-dimethylphenol	94 J

J = numerical value is an estimate because quality control criteria were not met.

Sediments (Table 8)--Polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and isophorone were the only organic compounds commonly detected in drainage sediments. 1,2-Dichlorobenzene (760 ug/Kg), 1,4-dichlorobenzene (400 ug/Kg), phenol (250 ug/Kg), and 2,4-dimethylphenol (220 ug/Kg) were detected in sediments from the 100th St. Ditch--again probably due to the spill. As described above, the dichlorobenzene isomers and dimethylphenol were also detected in ditch water samples.

Comparable detection limits were not achieved among sediment samples analyzed for acid/base/neutral compounds. The laboratory attributed the high detection limits for Boeing Pond, the S.E. Retention Pond, Swamp Creek, and Marshy Lake to dilution required by interfering compounds, predominantly from "hydrocarbons typical of those found in aviation fuels and lubricating oils" (Huntamer 1988). As a result, the present survey did not constitute an adequate screen for acid/base/neutral compounds in the sediments of these drainages; contaminant levels could have equaled or exceeded the sediment criteria shown in Table 8 and not been detected. For sites where lower detection limits were achieved, only the M.P. 5 Drain sediments approached the lowest AET values for PAH and contamination by these compounds did not appear to occur further downstream at the mouth of Big Gulch.

Low concentrations (25-130 ug/Kg) of isophorone, a solvent, were detected in sediments from Japanese Gulch and the Swamp Creek drainage. Isophorone is infrequently detected in Puget Sound sediments (PTI Environmental Services 1988). No AET values or other criteria were available to assess the significance of its occurrence in these drainage basins.

High concentrations (20,500 ug/Kg) of PCB, quantified as Arochlor-1254*, were measured in sediments from Boeing Pond outlet. This concentration exceeds the highest Puget Sound AET for PCB (3,100 ug/Kg). Neff *et al.* (1986) have proposed a freshwater sediment criteria for PCB of 290,000 ug/Kg TOC (i.e., normalized to TOC). This criterion, based on field data, is the highest concentration that 95% of freshwater benthic infauna were found to tolerate. When the Boeing Pond PCB concentration is normalized to TOC (490,000 ug/Kg TOC) it also exceeds this criterion. In spite of high PCB concentrations at the outlet from Boeing Pond, only trace PCB contamination (44 ug/kg) was observed in sediments at the mouth of Powder Mill Gulch.

Moderately elevated PCB concentrations were detected in the Swamp Creek drainage (1,450 ug/Kg), Marshy Lake (820 ug/Kg), and Paine Field Runway Retention Basin (280 ug/Kg). The PCB mixture in the Marshy Lake sediments resembled Arochlor-1260 rather than -1254 as at other sites. Low levels of PCB were also detectable in 100th St. Ditch sediments (84 ug/Kg). PCB were not detected at the mouth of Japanese Gulch below the Runway Retention Basin (20 ug/Kg detection limit).

---

* The first two numbers of the four digit number designating different Arochlors refer to the two 6-carbon rings of the biphenyl molecule; the second two numbers refer to percent chlorine by weight.

Table 8. Organic compounds detected in sediment samples collected from Paine Field drainages August 1987 compared to criteria for contaminated sediments (ug/Kg, dry; ppb).

Drainage:	Big Gulch			Japanese Gulch			Powder Mill Gulch				
Location:	Mile Post 5 Drain	Pistol Range Drain	Mouth	Runway Retention Basin Outlet	Mouth	Mouth (Replicate)	Boeing Retention Pond Outlet	Mouth		Puget Sound AET Values[b]	
Date:	8/10	8/10	8/10	8/11	8/10	8/10	8/11	8/11			
Time:	11:00	11:30	12:05	15:00	13:55	14:00	09:15	11:15	Freshwater Sediment Criteria[a]	Lowest AET	Highest AET	Urban Street Dust[c]
Sample No. (33-):	8161	8163	8164	8166	8167	8168	8173	8174				
% Fines[d]	34.85	20.13	50.32	18.94	10.71	7.66	48.04	9.15				
% TOC	1.5	1.0	0.5	0.8	1.4	0.8	4.2	0.5				
% Moisture	52.9	21.7	35.9	1.0	53.8	42.5	49.6	24.6				
Low Molecular Wt. PAH:[e]												
fluorene	1900U	240U	230U	250U	400U	300U	4800U	280U	--	540	3600	230
phenanthrene	**560J**	**26J**	230U	250U	400U	**26J**	**1000J**	280U	--	1500	6900	1500
High Molecular Wt. PAH:												
fluoranthene	**1000J**	240U	230U	250U	**23J**	**51J**	4800U	280U	--	2500	41700	1700
pyrene	**1200J**	240U	230U	250U	400U	**80J**	4800U	280U	--	2600	16000	1700
benzo(a)anthracene	**530J**	240U	230U	250U	400U	300U	4800U	280U	--	1300	5100	630
chrysene	**500J**	240U	230U	250U	400U	300U	4800U	280U	--	1400	9200	1000
benzo(a)pyrene	**390J**	240U	230U	250U	400U	300U	4800U	280U	--	1600	3600	630
indeno(1,2,3-c,d)pyrene	1900U	240U	230U	250U	400U	300U	4800U	280U	--	600	2600	--
Chlorinated Compounds:												
1,2-dichlorobenzene	1900U	240U	230U	250U	400U	300U	4800U	280U	--	35	>110	--
1,4-dichlorobenzene	1900U	240U	230U	250U	400U	300U	4800U	280U	--	110	120	--
Phenols:												
phenol	1900U	240U	230U	250U	400U	300U	4800U	280U	--	420	1200	210
2,4-dimethylphenol	1900U	240U	230U	250U	400U	300U	4800U	280U	--	29	210	20
Miscellaneous Extractables:												
isophorone	1900U	240U	230U	**82J**	**36J**	**25J**	4800U	280U	--	--	--	--
Polychlorinated biphenyls:												
PCB-1254	20U	20U	20U	**280**	20U	20U	**20500***	**44**	290,000[f]	130[g]	3100[g]	--
PCB-1260	20U	20U	20U	20U	20U	20U	1000U	15U	290,000[f]	130[g]	3100[g]	--

Table 8 (continued).

Drainage:	Stickney Lake			Swamp Creek	Marshy Lake		
Location:	100th St SE Ditch	SE Retention Pond Outlet	N. End of Lake	Bev. Pk./ Edmonds Rd.	E. Side of Runway		
Date:	8/10	8/11	8/11	8/10	8/11	Freshwater Sediment Criteria[a]	Urban Street Dust[c]
Time:	16:30	16:30	13:45	16:45	16:00		
Sample No. (33-):	8176	8177	8178	8180	8160		
% Fines[d]	5.47	89.64	86.92	39.80	94.25		
% TOC	0.6	2.6	15	19	2.2		
% Moisture	76.5	42.7	13.5	30.4	61.8		
Low Molecular Wt. PAH[e]:							
fluorene	**55J**	950U	2000U	1900U	1300U	--	230
phenanthrene	**420J**	950U	2000U	1900U	1300U	--	1500
High Molecular Wt. PAH:							
fluoranthene	**680J**	950U	2000U	1900U	1300U	--	1700
pyrene	**620J**	950U	2000U	1900U	1300U	--	1700
benzo(a)anthracene	550U	950U	2000U	1900U	1300U	--	630
chrysene	**280J**	950U	2000U	1900U	1300U	--	1000
benzo(a)pyrene	**340J**	950U	2000U	1900U	1300U	--	630
indeno(1,2,3-c,d)pyrene	**150J**	950U	2000U	1900U	1300U	--	--
Chlorinated Compounds:							
1,2-dichlorobenzene	**760J**	950U	2000U	1900U	1300U	--	--
1,4-dichlorobenzene	**400J**	950U	2000U	1900U	1300U	--	--
Phenols:							
phenol	**250J**	950U	2000U	1900U	1300U	--	210
2,4-dimethylphenol	**220J**	950U	2000U	1900U	1300U	--	20
Miscellaneous Extractables:							
isophorone	550U	950U	2000U	**130J**	1300U	--	--
Polychlorinated biphenyls:							
PCB-1254	**84**	200U	20U	**1450**	20U	290,000[f]	--
PCB-1260	20U	200U	20U	20U	**820**	290,000[f]	--

Note: Puget Sound AET's not applicable to above drainages

Table 8 (continued).

U = not detected, numerical value given is limit of quantification
J = numerical value given is an estimate because quality control criteria were not met
* exceeds sediment criteria

[a] estimated highest concentration that approximately 95% of benthic infauna can tolerate (Neff et al. 1986)

[b] apparent effects threshold; concentrations above which statistically significant biological effects occur in all samples analyzed (Tetra Tech, 1988)

[c] mean of 12 samples from Seattle and Bellevue (Galvin and Moore 1982)

[d] silt + clay (<62 um)

[e] polyaromatic hydrocarbons

[f] TOC-normalized concentration (ug/Kg TOC)

[g] total PCB's

The Ecology Northwest Regional Office was notified of these PCB findings December 8, 1987, when the data were received from the laboratory (Johnson 1987). Boeing, when informed of the contamination, voluntarily removed the sediments from the retention pond outlet structure and shipped them to the Arlington hazardous waste facility (Ashley 1988, personal communication). At present, Ecology inspectors are not aware of current or historical sources of PCB at Boeing (Ashley 1988, personal communication).

Tentatively Identified Organic Compounds

Nine additional non-target compounds were tentatively identified in the acid/base/neutrals fraction of Paine Field water and sediment samples (Table 9). The Merck Index (Windholz *et al.* 1983) and Registry for Toxic Effects of Chemical Substances (NIOSH 1983) contained information on four of these compounds. 2-Chlorophosphate(3:1)ethanol, a fire retardant, was tentatively identified (2 ug/L) in water from Boeing Pond, along with what appears to be a related compound, 2-butoxyphosphate(3:1)ethanol (8 ug/L). Water from the 100th St. Ditch tentatively contained a,a,4-trimethyl-3-cyclohexene-1-methanol, also known as a-terpineol, a compound found in various plant oils. Hexadecanoic acid, mono(2-ethylhexyl)ester was tentatively identified in sediments from the 100th St. Ditch and Stickney Lake. Decanoic acids are naturally occurring fatty acids found in animal and vegetable fats and oils. Finally, 2-chloro-4,6-bis(ethylamino)-s-triazine, the herbicide simazine and was tentatively identified at a high concentration (31,000 ug/Kg) in the sediments of M.P. 5 Drain.

Sediment and water from M.P.5 Drain were re-sampled March 29, 1989. Simazine was detected in the water sample at 0.17 ug/L; but not detected in sediment (76 ug/Kg detection limit). Simazine toxicity to fish and aquatic invertebrates typically occurs at concentrations that exceed 1,000 ug/L (Johnson and Finley 1980).

Bioassay of Drainage Water and Sediments

Bioassays were conducted on water and/or sediment from all sampling sites (Table 10). Water samples from Paine Field drainages were essentially non-toxic to *Daphnia*, except for the 100th St. Ditch where all *Daphnia* were killed during 48-hour exposure. A bioassay was not done on sediments from this ditch.

Sediment bioassays were limited to samples from the mouths of Big Gulch, Japanese Gulch, and Powder Mill Gulch, and Stickney and Marshy Lakes. *Hyalella* experienced good survival (i.e. comparable to laboratory control sediments) during 10-day exposure to all sediments except those from the mouth of Big Gulch. Percent survival for this site was 77% +/- 15%, but the analyst tentatively attributed this to difficulty in recovering the test organisms from this particular sample (Stinson 1987).

Paine Field Drainage as a Contaminant Source to Puget Sound

Questions about potential adverse impacts of Paine Field drainage to the local marine environment were raised during a recent evaluation of potential contaminant sources to

Table 9. Organic compounds tentatively identified in water and sediment samples collected from Paine Field drainages, August 1987 (ppb).

Drainage	Location	Date	Time	Sample No. (33-)	Compound	CAS No.[a]	Concentration
WATER SAMPLES (ug/L):							
Powder Mill Gulch	Boeing Retention Pond Outlet	8/12	10:45	8179	2-chloro-phosphate (3:1) ethanol	115-96-8	2 J
	Boeing Retention Pond Outlet	8/12	10:45	8179	2-butoxy-phosphate (3:1) ethanol	78-51-3	8 J
Stickney Lake	100th St SE Ditch	8/10	16:30	8181	a,a,4-trimethyl-3-cyclohexene-1-methanol	1048-56-1	7,600 J
	100th St SE Ditch	8/10	16:30	8181	7-(dimethylamino)-4-methyl-2H-1-benzopryan-2-one	91-44-1	250 J
SEDIMENT SAMPLES (ug/Kg, dry):							
Big Gulch	Mile Post 5 Drain	8/10	11:00	8161	2-chloro-4,6-bis (ethylamino)-s-triazine	122-34-9	31,000 J
	Pistol Range Drain	8/10	11:30	8163	4-methylene-1-(1-methylethyl)-bicyclohexane	--	2,000 J
	Pistol Range Drain	8/10	11:30	8163	4b,5,6,7,8,8A,9,10-octahydro-4B,5,8-trimethyl phenanthrenol	511-15-9	2,000 J
Powder Mill Gulch	Boeing Retention Pond Outlet	8/11	09:15	8173	decahydro-2-methylnaphthalene	--	53,000 J
Stickney Lake	100th St SE Ditch	8/10	16:30	8176	hexadeconoic acid, mono(2-ethylhexyl)ester	4337-65-19	50,000 J
	N. End of Lake	8/11	13:45	8178	hexadeconoic acid, mono(2-ethylhexyl)ester	4337-65-19	570,000 J

J = estimated concentration

[a] Chemical Abstracts Registry Number

Table 10. Bioassay results on water and sediment samples collected at Paine Field, August 1987 (mean % survival ± SD)

Drainage:	Big Gulch			Japanese Gulch			Powder Mill Gulch	
Location:	Mile Post 5 Drain	Pistol Range Drain	Mouth	Runway Retention Outlet Basin	Mouth	Mouth (Replicate)	Boeing Retention Pond Outlet	Mouth
Water Sample No. (33-):	8162	(dry)	8165	(dry)	8169	8170	8179	8175
Date:	8/10		8/10		8/10	8/10	8/12	8/11
Time:	11:00		12:05		13:55	14:00	10:45	11:15
Daphnia Survival[a]	100±0		95±6		100±0	NA	100±0	100±0
Sediment Sample No. (33-):	8161	8163	8164	8166	8167	8168	8173	8174
Date:	8/10	8/10	8/10	8/11	8/10	8/10	8/11	8/11
Time:	11:00	11:30	12:05	15:00	13:55	14:00	09:15	11:15
Hyalella Survival[b]	NA	NA	77±15	NA	83±15	NA	NA	87±6

Drainage:	Stickney Lake			Swamp Creek	Marshy Lake	Labor-
Location:	100th St SE Ditch	SE Reten- tion Pond	N. End of Lake	Bev. Pk./ Edmonds Rd.	East side of Runway	atory Control
Water Sample No. (33-):	8181	8182	(not sampled)	(dry)	(not sampled)	--
Date:	8/10	8/12				--
Time:	16:30	11:30				--
Daphnia Survival	0	100±0				95±6
Sediment Sample No. (33-):	8176	8177	8178	8180	8160	--
Date:	8/10	8/11	8/11	8/10	8/11	--
Time:	16:30	16:30	13:45	16:45	16:00	--
Hyalella Survival	NA	NA	93±6	NA	83±6	93±6

[a] n = 4

[b] n = 3

NA = not analyzed

Everett Harbor (Tetra Tech 1988a). At the time that source evaluation was conducted only limited data from the present survey were available.

As part of the Everett Harbor action program, Tetra Tech (1988c) surveyed Port Gardner nearshore sediments off Japanese Gulch and Powder Mill Gulch for chemical contaminants and a range of biological indicators (Figure 4). Malins *et al.* (1985) also sampled two stations off Mukilteo for sediment chemistry and fish histopathology (Figure 4). Possession Sound sediments off the mouth of Big Gulch have not been surveyed.

Potential problems identified by Tetra Tech and Malins *et al.* in nearshore Port Gardner were primarily limited to elevated concentrations of several organic chemicals (Table 11) and liver lesions in fish. Elevated metals concentrations and significant depressions in abundance of benthic infauna were not observed. Significant amphipod (*Rhepoxynius abronius*) mortalities in sediment bioassays occurred at only two stations, NG-04 and NG-06 (100% and 43%, respectively). Both of these sites are off the mouth of Japanese Gulch and near the defense fuel storage depot. The prevalence of liver lesions in English sole (*Parophrys vetulus*) collected by Tetra Tech were elevated above reference values, but differences were not statistically significant. An increased incidence of liver lesions was also reported by Malins *et al.* for English sole collected off Mukilteo.

Problem chemicals in nearshore Port Gardner sediments were 4-methylphenol (six stations), phenol (four stations), benzoic acid and low molecular weight PAH (three stations each), and high molecular weight PAH and PCB (one station each). As shown in Table 11, analysis of sediments for the present survey showed that all of these chemicals were near or below detection limits at the mouths of Japanese Gulch and Powder Mill Gulch. In the case of benzoic acid, detection limits were not sufficiently low to rule out either gulch as a source, however, the spatial distribution of benzoic acid in Port Gardner sediments suggests at least Powder Mill Gulch is an unlikely source. Similarly, while the detection of high PCB concentrations in sediments from Boeing Pond suggest this is, or may have been, a significant source, marine sediments near the mouth of Powder Mill Gulch (NG-14 and NG-03) do not have elevated PCB concentrations. Although the fuel depot is suspected as a source of one or more problem chemicals, Tetra Tech was unable to identify the source(s) of sediment contamination in nearshore Port Gardner--other than to conclude that the source was local rather than from Everett's highly contaminated East Waterway (Tetra Tech 1988a).

SUMMARY OF FINDINGS

The major problems identified through Ecology's August 1987 survey of Paine Field drainage basins were as follows:

1. Sediments at the outlet of the Boeing Retention Pond discharge to Powder Mill Gulch had very high concentrations of PCB (20,500 ug/Kg). Boeing Pond was also a potential source of cadmium, lead, mercury, and zinc to the gulch. Only zinc, however, appeared substantially elevated in sediment at the mouth of Powder Mill Gulch. A trace amount of PCB (44 ug/Kg) was detected at the mouth.

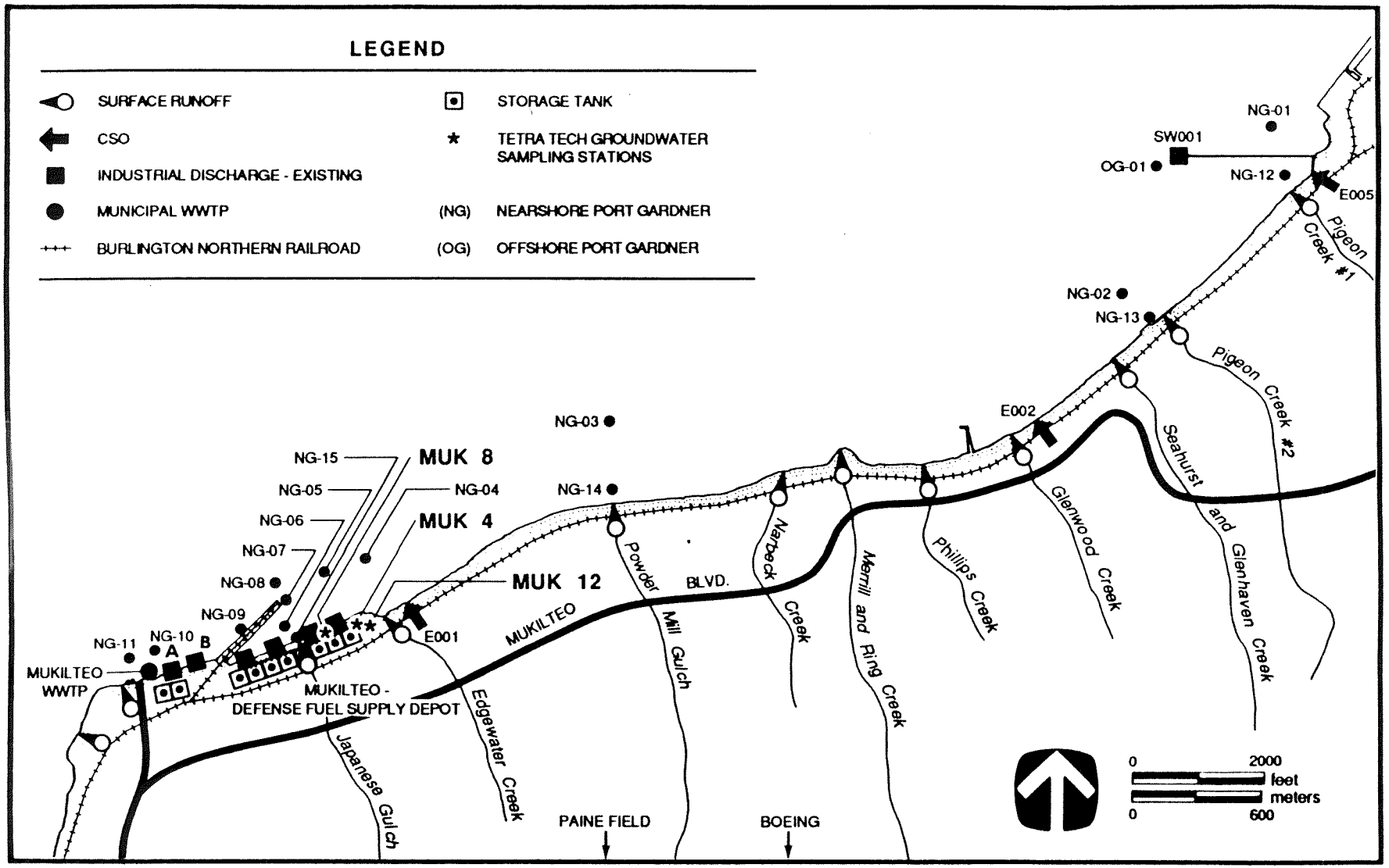

Figure 4. Tetra Tech (NG-) and NOAA (A and B) sediment sampling stations in nearshore Port Gardner (from Tetra Tech 1988a)

Table 11. Problem chemicals in nearshore Port Gardner sediments compared to present survey results for Japanese Gulch and Powder Mill Gulch sediments - modified from Tetra Tech (1988a) (ug/Kg dry; ppb).

Station No.	Location	Low Molecular Weight PAH[a]	High Molecular Weight PAH[b]	4-Methylphenol	Phenol	Benzoic acid	PCB
NG-14	50' from Powder Mill Gulch outfall (intertidal)			2,100**	1,200*		
NG-04	East of Mukilteo Fuel Depot			2,400**			
NG-05	NW end Mukilteo Fuel Depot			9,700**		2,100**	
NG-07	End of Mukilteo Fuel Dock					1,700**	
NG-08	NW Pier off Oil Tanks					1,300**	
NG-09	Near Fuel Dock	510* (acenaphthene)		2,400**	2,100**		5,500**
B	Near Fuel Tanks	10,600**	15,500*				200*
NG-10	Off NMFS Mukilteo Lab			1,800**	1,000*		
NG-11	West of Mukilteo Ferry Dock	560* (acenaphthene) 610* (fluorene)		1,600**	1,100*		
--	Japanese Gulch Mouth (present survey)	300U-400U (26J phenanthene)	300U-400U (23J-51J fluoranthene; 80J pyrene)	300U-400U	300U-400U	1,500U-2,000U	20U
--	Powder Mill Gulch Mouth (present survey)	280U	280U	280U	300U	1,400U	44

U = not detected
J = estimated concentration

[a] sum of naphthalene acenaphthylene, acenaphthene, phenanthrene and anthracene

[b] sum of fluoranthene, pyrene, benzu(a)anthracene, chrysene, benzo(a)pyrene, perylene, dibenzo(a,h)anthracene, benzofluoranthenes, idenopyrene, benzo(g,h,i)perylene

* exceeds lowest AET value
** exceeds highest AET value

2. Sediments in the M.P. 5 Drain to Big Gulch appeared to be contaminated with the herbicide simazine. The presence of simazine was recently confirmed in a March 1989 water sample which had a concentration of 0.17 ug/L. General water quality in the drain was also very poor, as evidenced by the presence of foam, a reddish-brown floc on the bottom, and high specific conductivity, ammonia, hardness, and TOC.

3. Water and sediments in the 100th St. S.E. Ditch were contaminated by a range of metals and organic chemicals. A bioassay with *Daphnia pulex* showed the water was acutely toxic. A spill of cutting fluid at Paine Field was the likely source of one or more chemical contaminants and probable reason for toxicity.

4. Moderately elevated concentrations of PCB were detected in sediments collected from upper Swamp Creek drainage (1,450 ug/Kg), Marshy Lake (820 ug/Kg), and the Paine Field Runway Retention Basin (280 ug/Kg).

5. Sediments in Stickney Lake had elevated concentrations of arsenic (21 mg/Kg), lead (175 mg/Kg), mercury (0.39 mg/Kg), and zinc (352 mg/Kg).

6. An elevated mercury concentration (0.22 ug/L) was measured in water from the mouth of Big Gulch.

7. Elevated concentrations of mercury (0.28 ug/L) and total cyanide (48 ug/L) were detected in the discharge from the Paine Field S.E. Retention Pond.

8. Phosphorus concentrations in water samples from Japanese Gulch, Powder Mill Gulch, the 100th St. S.E. Ditch, and Paine Field S.E. Retention Pond were sufficient to cause nuisance plant growths. Boeing Pond was a phosphorus source to Powder Mill Gulch, however additional unidentified sources appeared to exist in the drainage.

9. Although Japanese Gulch and Powder Mill Gulch did not appear to be current sources of the chemical contamination that has been reported in nearshore Port Gardner sediments off Mukilteo, the poor detection limits encountered for benzoic acid in Japanese Gulch sediments preclude ruling out this drainage as a source of this compound.

RECOMMENDATIONS

High Priority:

1. A survey of PCB concentrations in the sediments and soils of Powder Mill Gulch drainage basin should be conducted to determine if PCB sources currently exist and evaluate the extent of contamination downstream of the Boeing Retention Pond.

2. Boeing should do routine monitoring of EPA priority pollutants/HSL compounds in the retention pond discharge to Powder Mill Gulch. Sediments at the outlet structure should be analyzed twice-a-year for acid/base/neutrals (including spectral match of major

unidentified peaks), PCB, and metals; water samples should be analyzed quarterly for metals, volatile compounds, selected conventional variables including nutrients, total suspended solids, and flow. The monitoring program should be reduced or intensified as dictated by accumulating data.

3. The source of simazine and generally poor water quality in the M.P. 5 Drain to Big Gulch should be investigated.

Medium Priority:

1. Additional sediment samples should be collected in Stickney Lake to confirm elevated concentrations of arsenic, lead, mercury, and zinc and assess the extent of contamination.

2. Water samples from the mouth of Big Gulch should be re-sampled and analyzed to confirm an elevated concentration of mercury.

3. Water from the Paine Field S.E. Retention Pond should be re-sampled and analyzed to confirm elevated concentrations of mercury and cyanide.

Low Priority:

1. Sediments from the mouth of Japanese Gulch, Boeing Pond, the S.E. Paine Field Retention Pond, Swamp Creek, and Marshy Lake should be re-sampled and analyzed for acid/base/neutrals at lower detection limits than achieved in the present survey. Particular attention should be paid to the occurrence of benzoic acid in Japanese Gulch sediments and its potential as a source of sediment contamination in nearshore Port Gardner.

REFERENCES

APHA. 1985. Standard Methods for the Examination of Water and Wastewater. Washington, D.C.

Ashley, L. 1987-88. Personal Communications. Washington Department of Ecology. Northwest Regional Office.

EPA. 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

EPA. 1984. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule. CFR v.49 n.209.

EPA. 1985a. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. EPA-600/4-85-013.

EPA. 1985b. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water. EPA/600/6-85/002.

EPA. 1986a. Test Methods for Evaluating Solid Waste, SW-846. Office of Emergency Response. Washington, D.C.

EPA 1986b. Quality Criteria for Water, 1986. EPA 400/5-86-001.

Galvin, D.V. and R.K. Moore. 1982. Toxicants in Urban Runoff. Metro Toxicant Program Report No. 2. Municipality of Metropolitan Seattle. Seattle, Washington.

Holme, N.A. and A.D. McIntyre. 1971. Methods for Study of the Marine Benthos. Internat. Biol. Prog. Handbook No. 16.

Huntamer, D. 1986. Laboratory User's Manual. Washington Department of Ecology, Manchester, Washington.

Huntamer, D. 1988. Paine Field Soil Detection Limits. Washington Department of Ecology memorandum to A. Johnson.

Johnson, A. 1987. Paine Field PCB Data. Washington Department Ecology memorandum to L. Ashley.

Johnson, W. W. and M.T. Finley. 1986. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. U.S. Fish and Wildlife Service. Resource Pub. 137. Washington, D.C.

Kirchmer, C. 1988. Quality Assurance Manual, Manchester Laboratory. Washington Department of Ecology, Manchester, Washington.

Malins, D.C., M.M. Krahn, D.W. Brown, L.D. Rhodes, M.Meyers, B.B. McCain, and S.L. Chan. 1985. Toxic Chemicals in Marine Sediment and Biota from Mukilteo, Washington: Relationships with Hepatic Neoplasms and Other Hepatic Lesions in English Sole (*Parophrys vetulus*). J. Nat. Cancer Inst. 74(2):487-494.

Nebeker, A.V., M.A. Cairns, J.H. Gakstatter, K.W. Malueg, G.S. Schuytema, and D.F. Krawgzyk. 1984. Biological Methods for Determining Toxicity of Contaminated Sediments to Invertebrates. Environ. Toxicol. Chem. 3:617-630.

Neff, J.M., D.I. Bean, B.W. Cornaby, R.M. Vega, T.C. Gulbraunsen, and J.A. Scanlon. 1986. Sediment Quality Criteria Methodology Validation: Calculation of Screening Level Concentrations from Field Data. Battelle, Washington, D.C.

NIOSH. 1983. Registry of Toxic Effects of Chemical Substances. Nat. Inst. for Occup. Safety and Health, USPHS. Cincinnati, OH.

NOAA. 1987. Hourly Precipitation Data. Washington Nat. Climactic Data Center, Ashville, N.C. v.37 n.7 and 8.

PTI Environmental Services. 1988 (Draft). Sediment Quality Values Refinement: Tasks 3 and 5 - 1988 Update and Evaluation of Puget Sound AET. Prepared for EPA Region X - Office of Puget Sound, Seattle, Washington.

Stinson, M. 1987. Paine Field Runoff Study: Bioassay Results. Washington Department of Ecology memorandum to A. Johnson.

Tetra Tech. 1986. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Prepared for EPA Region X and U.S. Army Corps of Engineers. Seattle, Washington.

Tetra Tech. 1988a. Everett Harbor Action Program: Evaluation of Potential Contaminant Sources. Prepared for EPA Region X - Office of Puget Sound, Seattle, Washington.

Tetra Tech. 1988b. Elliot Bay Action Program: Storm Drain Monitoring Approach. Prepared for EPA Region X - Office of Puget Sound, Seattle, Washington.

Tetra Tech. 1988c. Everett Harbor Action Program: Analysis of Toxic Problem Areas. Prepared for EPA Region X - Office of Puget Sound, Seattle, Washington.

Windholz, M. (Editor). 1983. The Merck Index. Merck & Company, Rathway, New Jersey.

Wisconsin Department Natural Resources. 1985. Report of the Technical Subcommittee on Determination of Dredge Material Suitability for In-water Disposal. Madison, Wisconsin.